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ENGINEERING SUPPORT TO THE OPERATIONS OF ROCKET TROOPS IN AN OFFENSIVE

by Col. K LAPSHIN

In modern offensive operations the combat actions of rocket troops, because of the mass use of nuclear weapons, will, it is generally agreed, take place in difficult circumstances. It may be assumed that the deployment of rocket units and their operations will be carried out under conditions of great destruction of roads, bridges and water-crossings, the outbreak of extensive fires in towns and forests, and wide-spread radioactive contamination of the ground. Unless effective measures are undertaken to reduce the unfavorable effects of these factors, the combat and maneuver capabilities of the rocket troops will be greatly reduced.

Rocket troops are the main means of fire-power in an offensive operation. Therefore the defending side naturally will do everything possible to inflict an attack first of all on the rocket weapons, using nuclear and conventional weapons, various kinds of landing and even diversionary forms of attack.

Hence we may conclude that in an offensive there will arise such critical problems as providing for rapid maneuver, dependable anti-nuclear protection, constant readiness to fight against landings and diversionary-and-intelligence groups of the enemy. These problems are met by various measures, including engineering ones.

The increased scope and high speeds of an offensive operation make a number of operational demands on the engineering support of the combat operations of rocket troops. It is very important that the engineering measures be carried out in the briefest time, and in a timely and concealed manner, otherwise they will not assure the readiness of the units for rocket launching. It is especially necessary to prepare quickly routes of movement and areas of deployment.

In the zone of attack, as in known there is created a ramified network of frontal and lateral routes of movement. For movement of the rockets to the areas of deployment, it is desirable to allot to them the best routes, and by order of the senior command keep them free for a certain period of time from the movement of other troops and military loads. This measure will facilitate the unhindered and rapid movement of the rocket troops into the designated areas and the timely bringing up of the rockets.

However, even with roads prepared in advance, the movement of rocket troops will often meet with difficulties. There may be destruction and radioactive contamination of the roads from nuclear attacks. There may also be expected the use by the side on the defensive of mine and explosive obstacles, arranged on the communication routes of the attackers by the retreating troops, by [illegible] and [illegible] troops. Therefore various kinds of road work may be necessary on the routes of movement of the rocket units. The clearing away of forest obstacles, decontamination of the roadways, and extinguishing of fires will be especially difficult.

In order that destruction on the roads may not disrupt the timely moving up of the rocket troops into the areas of deployment, it is important constantly to provide for measures to assure the direct movement of columns on the march. In particular, it is advisable in the rocket troops to create, from the engineering podrazdeleniya, movement support detachments (OOD), like those which are organized in the ground troops. these detachments, moving at the head of the column, will remove obstacles and destruction which may be created even after the passage of the reconnaissance podrazdeleniya.

In presenting the problem of creating the OOD, we foresee possible objections. But it is not a matter of what to call the engineer podrazdeleniya which move ahead of the column of rocket weapons: whether OOD or something else. After all, it is important that there be at the head of the column on the march engineering units with the necessary equipment--road mine-detectors, road layers, mechanized bridges, etc.

Also of great importance for increasing the speed of movement of rocket troops is the training of personnel in simple road work in negotiating difficult-to-traverse sections of the route, in rendering quick assistance to drivers of combat and transport vehicles, and in the use of means of increasing the roadability (prokhodimost') of equipment--tow ropes and other devices for pulling out stuck vehicles.

In the position areas of the rocket troops it is also necessary to prepare roads, linking together the elements of the combat formation. The extent of these is fairly great; therefore their preparation is beyond the capabilities of the rocket chasti and podrazdeleniya. It is especially difficult to do this on terrain which has previously been occupied by the enemy, because on withdrawing, he will probably mine or destroy the roads. Here arises the necessity of calling on the forces and resources of the senior combined-arms commander. It is desirable to prepare the routes quickly, in advance of the arrival of the rocket weapons. When there is a comparatively small amount of road work to be done, this is possible. In our opinion it is of great importance correctly to select the areas to be occupied by the rocket troops during the offensive, so as to reduce the amount of engineering work for organizing these areas.

In an offensive operation, for troops of the first echelon there is usually provided preparation of a road network, checking of the terrain for mines, and other engineering measures in support of their combat operations. In the interests of speeding up the preparation of routes, it is advisable to locate the position areas of rocket troops in places where the terrain has been at least partially cleared of mines and where routes have been prepared by troops operating ahead. This makes it possible to reduce the amount of road and bridge operations and speed up the preparation of the position areas.

Correct selection of areas for rocket troop deployment is possible if timely information is received on destruction and obstacles in the depth of the enemy's defense. Therefore it is very important to conduct engineering reconnaissance through the whole depth of the operation, and quickly report the information obtained to the rocket troops. This will help in making well-founded decisions as to the combat use of rockets and engineering support of the operations of the rocket troops.

A difficult problem, requiring continuous further investigation, is that of increasing the survivability of rocket troops in a modern offensive operation. Engineering preparation of the areas of deployment and their concealment are prominent among various measures of antinuclear protection. Here the amount of engineering work sharply increases inasmuch as it is necessary to erect a great number of various installations, especially for protection of personnel and combat equipment. But the brief periods of time during which the engineering preparation has to be accomplished often does not allow this to be done.

Therefore, increase of the survivability of rocket troops can be acheived only by a complex of operational and engineering and technical measures for their antinuclear protection. Among the basic operational measures are the designation of launch sites in places which have advantageous protective features, the determination of the optimun distance between elements of the combat formation, planning and carrying out timely anti-nuclear maneuvers, selecting the places for disposition of the rocket weapons in relation to the other elements of the operational formation, etc. Each of these measures has its definite engineering aspects.

It is advantageous to select the positions area for rocket troops in terrain with good natural protection and concealment, which can reduce somewhat the total amount of engineering work. A dispersed combat formation is of great importance for antinuclear protection. However, we know that such dispersal must be confined to certain limits, in order not to reduce the combat capabilities of the rocket troops and not to create difficulties of command and of cooperation between elements of the combat formation.

The degree of dispersal is usually established with consideration of the terrain features and the completeness of the engineering organization of the ground. The more complete the latter is, the less the dispersal needed. However, research shows that there is no simple direct relationship

of the engineering organization of the ground and the degree of possible dispersal of the troops.

It would be much simpler to establish such a relationship if in the rocket troop deployment areas were constructed personnel cover of a single type, for example, only shelters (ubezhishcha), or only slit trenches. The relationship between the protective qualities of various kinds of cover for personnel and the dispersal of elements of the combat formation may be mathematically expressed as follows $\frac{L_1}{R_1} = \frac{L_2}{R_2} = \frac{L_3}{R_3} = \frac{L_4}{R_4} = \frac{L_{a.c}}{R_{a.c}}$ where L_1, L_2, L_3, and L_4 is the distance (in kilometers) between elements of the combat formation with cover for personnel consisting, respectively, of shelters, dugouts, covered slit trenches, and open slit trenches; R_1, R_2, R_3, and R_4 are the effective casualty (porazheniya) radii of the respective types of cover; $L_{a.c}$ is the distance between elements of the combat formation which provides safety with the disposition of personnel without cover; and $R_{a.c}$ is the effective casualty radius with the latter dispositon of personnel.

Let us consider an example. Suppose that in the engineering organ-- zation of the position area there are built personnel shelters for which the effective casualty radius, with a 30-kiloton nuclear blast, is $R_1 = 0.5$ km, as set forth in US military literature[1]. According to these data, an adequately safe distance between elements of the combat formation is $L_1 = 3$ km. Let us determine the necessary dispersal for the same degree of protection if it is possible to provide, instead of shelters, only covered slit trenches for the troops. The effective casualty radius for such cover, with a nuclear blast of the same power[2] is taken as: $R_3 = 1.1$ km. From the ratio $\frac{L_1}{R_1} = \frac{L_3}{R_3}$ we get $L_3 = L_1 \times \frac{R_3}{R_1} = 3 \times \frac{1.1}{0.5} = 6.6$ km.

Consequently, with covered slit trenches, less effective for cover than shelters, the distance between elements of the combat formation must be increased 2.2 times.

Let us determine what the dispersal would have to be to obtain the same degree of protection of personnel as in the second case, if there were no engineering preparation of the terrain at all. According to US data[3], the effective casualty radius for personnel outside of any kind of cover is $R_{r.c} = 2.2$ km. From an analogous ratio we get $L_{r.c} = L_3 \frac{R_{r.c.}}{R_3} = 6.6 \frac{2.2}{1.1} = 13.2$ km.

The calculations show that with disposition of personnel out in the open, the distance between elements of the combat formation will be 4.4 times as great as if they were in shelters, and twice as great as if they were in covered slit trenches. Wish such dispersal, the size of the position area of rocket chasti and podrazdeleniya greatly increases, and fire control and direction of the podrazdeleniya deteriorates. Such dispersal in a combat situation, obviously, is not realistic. At the same time the examples show that just by dispersal alone without engineering organization of the ground, it is impossible to provide dependable anti-nuclear protection of the troops. In military literature sometimes unjustified importance is given to dispersal as a means of antinuclear protection.

The operational-tactical practice of planning and carrying out anti-nuclear maneuver has, in our opinion, great practical importance. This is accomplished by a periodic change of the areas occupied by the rockets. The success of this to a great extent depends on the speed and concealment of accomplishing it, and on its engineering support, which consists of timely preparation of routes for movement to alternate areas and organization of these areas.

The choice of the place for disposition of rocket units relative to other elements of the operational formation of the attacking forces also greatly affects their survivability. It is by no means a matter of indifference how far they are located from the disposition of the reserves, the second echelons, the real installations, large bridges, and other objectives which might attract the attention of enemy reconnaissance and be targets for his nuclear attacks. Location of the rockets at some distance from troops, populated places, main roads, and important targets facilitates their concealment and consequently increases the ability to survive both of individual elements of a combat formation and of the rocket troops as a whole.

Engineering-technical measures for antinuclear protection include, of course, engineering preparation and concealment of the position areas, and engineering measures for eliminating the consequences of nuclear attack by the enemy.

Engineering preparation of rocket troop position areas is the most practical way of achieving a high degree of their protection against nuclear attack. However, this conclusion is justifiable if the engineering preparation is carried out in short periods, conforming to the maneuver characteristics of the combat operations of the troops in general, and of the rocket troops in particular. Considering that these troops will be under constant threat of nuclear attack, it is very important to seek out various ways of rapid engineering preparation of position areas.

Speeding up organization of the ground always has been and still is of special concern to commanders at all levels, since it creates quickly the necessary conditions for protection of troops from weapons of mass destruction. The speeds of engineering preparation can be increased by comprehensive mechanization of the operations, by correct choice of the kind of engineering preparation, by allotting to rocket units the necessary amount of equipment which can be assembled and disassembled, adapted to being moved by all kinds of transport and at high speed, by mobilization of personnel for rapid carrying out of engineering operations, and by timely movement of engineering units into the work areas.

Of the measures listed, the most difficult to accomplish is the comprehensive mechanization of labor-consuming earth-digging operations. The construction by hand of even the simplest shelters requires the assignment to it of a great number of men. And this cannot be done, because rocket troops personnel as a rule are busy servicing the complicated rocket equipment and cannot be drawn off for engineering work. Therefore mechanization of the operations and choice of the kind of engineering work to be done and of the means of accomplishing it in a given situation have assumed great importance.

While the problem of mechanizing large-scale earth-moving operations has been successfully solved in the armies of all the leading countries, little has been done on the mechanization of such operations on a small scale. It is very important, for example, to mechanize the digging of pits for dugouts and the construction of slit trenches and trenches. For this are required excavating machines capable of doing this small-scale work, which will solve the problem of comprehensive mechanizaion, thereby reducing the personnel requirements for engineering preparation of positions.

The possibility of speeding up engineering organization of the ground to a great extent depends on skillful utilization of excavating equipment. Experience shows that use of engineering machines should be planned. It is especially important to set up a work schedule for trench-digging and road-laying machines. It should be realized that every hour of idle time of these machines because of poor organization of the work is reflected in the engineering preparation of the positions, and consequently results in a reduction of the protection afforded the troops. We think it necessary to reduce to a minimum unproductive movement and idle time of engineering machines.

Since engineering operations are usually accomplished by limited forces and in compressed periods of time, it is very important correctly to determine the kind of engineering preparation for the attainment of the greatest degree of protection. This determination is made, as we know, during reconnaissance. If circumstances permit, the staffs and combat engineers make a detailed estimate of the engineering preparation: they determine the number and kind of installations and facilities to be set up, and also the manpower, equipment and time required. Such calculations should be made during the period of preparation for the combat operations, and for the most typical cases and circumstances, even earlier.

Planning engineering preparation [illegible] organization of the operations, and for sound distribution and use of engineering manpower and equipment. However, existing methods of calculations, in our opinion, are laborious and do not make it possible in advance to evaluate the probable final result of engineering preparation of the ground.

First it should be said that the amount of engineering operations, which will often be limited by circumstances, should be determined by the quantity and kinds of installations or by an estimate of the possibility of accomplishing the planned operations with the available manpower and equipment in the assigned time. Here all the initial data are frequently refined in the process of the estimates in order, in the end, to plan such a volume of work as can be accomplished with the available manpower and equipment. Sometimes it is necessary to spend a comparatively long time in order to obtain the final result.

Here we have one of the serious shortcomings of the methods of calculations. Moreover, such calculations do not give the answer to the question, what degree of protection can be achieved in engineering preparation of position areas. The protection afforded the troops is often judged only by the protective qualities of the shelter installations erected in a given area. In our opinion, with such an approach it is possible to estimate only in general outline the acceptability of the engineering preparation of the terrain, i.e., to conclude that a better or a worse degree of protection of troops will be afforded by a certain preparation of the positions. To describe in quantitative (numerical) terms the degree of protection attainable does not seem possible.

Besides the protective capabilities of shelters, many factors, in combination, have an effect on the degree of protection of personnel: the dispersal of the combat formations, the force and number of nuclear blasts, etc. Changing the nature of the engineering preparation of positions and, within certain limits, the distances between them, may achieve the desired degree of protection.

In order fully to establish the interrelationship between all these factors, and to make a sound choice of the kind of engineering preparation of positions to achieve the necessary protection, it seems to us that in calculations of the engineering preparation of the terrain there should be made a quantitative and qualitative evaluation of the effectiveness of the antinuclear protection achievable as a result of a certain degree of engineering preparation of postions of rocket troops, and of their dispersal

For such an evaluation, it seems, there should be introduced a criterion which would describe the degree of protection of troops in terrain which has been prepared in an engineering sense. As such a criterion, in our opinion, we could take the mathematical [illegible] proportion of undamaged cover (M), as a result of a nuclear attack on the rocket troops areas of deployment. Thus, if the number M is equal to 0.8, this means that with a large number of nuclear attacks, the number of undamaged cover, attibutable on the average to one attack, will be 80 percent. However, with a single attack the actual number of undamaged cover may differ greatly from the average.

Strictly speaking, the proportion of undamaged shelters theoretically is an accidental value, depending on many causes--the kind of shelters, the dispersal of elements of the combat formation, the force and number of nuclear attacks, the deviation of the nuclear weapon from the target, etc At the same time, this criterion makes it possible numerically to determine the degree of protection of troops on prepared terrain.

The essence of the proposed method of calculating the engineering preparation of the terrain, taking into account the degree of protection afforded, consists in finding the relationship between the value M, the number of shelters of a certain type, on the one hand, and the available time, manpower and equipment for their construction, on the other. This relationship may be expressed by the following system of linear equations:

$$a_1z_1 + a_2z_2 + a_3z_3 + a_4z_4 \quad Z_pT \qquad (1)$$

$$z_1 + z_2 + z_3 + z_4 = 100 \qquad (2)$$

$$M_1z_1 + M_2z_2 + M_3z_3 + M_4z_4 = 100\ M_{cp.rc} \qquad (3)$$

The first equation (1) expressed the requirement for manpower for building the shelters. In this equation, Z_p is the percent of personnel allotted to work inbuilding shelters; T - the time of the in hours; a_1, a_2, a_3, a_4 = the expenditure of time in hours per protected person with the construction, respectively, of shelters, dugouts, covered slit trenches, or open slit trenches; z_1, z_2, z_3, z_4 = the percent of personnel placed, respectively, in shelters, dugouts, covered slit trenches, and open slit trenches in relation to the total number in the chast'' or podrazdeleniye.

The second equation (2) shows the percentage distribution of personnel by types of shelters.

The third equation (3) makes it possible to determine the degree of protection of personnel ($M_{cp.rc}$), where M_1, M_2, M_3, and M_4 is the mathematical expectation of the proportion of undamaged shelters by types (shelters, dugouts, covered slit trenches, open slit trenches). These values are determined according to table or graphs.

By this system of equations it is possible to solve a broad range of operational-engineering problems. For example, one of the most important problems is achieving the maximum possible protection of rocket troops' positions by engineering preparation of them in set periods of time and with limited manpower. Knowing these periods, the manpower, and the equipment, it is necessary to determine what number of shelters by types will afford the greatest protection under given conditions. Solution of the system of equations by the method of linear programming makes it possible to do this.

In an offensive operation another problem is often of great importance: with a degree of protection of the launching positions set by the senior commander, it is necessary to determine the kind of engineering preparation of them which will require a minimum expenditure of manpower and resources. This problem also is solved by linear programming.

There may arise other problems to be solved during combat operations. Thus, with degree of protection and time periods for preparation of rocket troop position areas assigned by the commander, there must be determined the required number of installations and the manpower and resources needed for their construction. Or, with an assigned time for completing the work and a known allotment of manpower, it must be determined how many shelters can be built and what will be the degree of protection.

Thus all the most frequently encountered problems in the engineering preparation of the ground for rocket troops can be mathematically solved by the system of equations. However, rapid solution of practical problems by equations under field conditions is possible only with the use of an electronic computer. Therefore, in our opinion, for making engineering calculations there is very great need for graphs, nomograms, and tables which will make it possible simply and quickly to determine the optimum kind of engineering preparation in a specific situation. The equations provided by us would be of substantial help in compiling these.

In engineering preparation of position areas, besides personnel shelters there is also prepared, of course, pit-type cover for combat equipment, and natural cover is used also. Calculation of the number of pits to be dug presents no difficulties. For estimate of the protection afforded combat equipment it is expendient to take as a criterion the mathematical expectation of the proportion of undamaged equipment ($M_{cp.t}$), determined by the formula:

$$M_{cp.t} = \frac{M_y N_y + M_o N_o}{100}$$

where M_y and M_o are the mathematical expectation of the proportion of undamaged equipment emplaced, respectively, with and without protective cove[illegible] combat equipment likewise having, respectively, protective cover, and no protective cover.

Having determined the value of $M_{cp.t}$, one may judge as to the degree of protection afforded combat equipment.

By the proposed calculations, we believe that commanders, staffs, and combat engineers will be able to select, for a given situation, the most advantageous engineering organization of the ground in view of the degree of protection required and the manpower, resources and time available. There will be less preliminary comparison of alternatives. This will make possible a saving of time for more careful organization and carrying out of the engineering operations, which in the final analysis will speed up the preparation of the position areas of rocket troops. Moreover, it will give rise to the possibility of more soundly and specifically assigning tasks of engineering preparation of positions to podrazdeleniya. Such methods of calculations will make it possible scientifically to foresee possible damage from nuclear attacks and to plan for the elimination of the consequences of a nuclear attack by the enemy.

Commanders of chasti and podrazdeleniya will be able independently, without the help of engineering officers, to determine quickly the kind and volume of engineering work for preparation of positions, which is especially important for those units where there are no combat engineers. Finally, such calculations will help commanders more correctly to distribute among the troops ready assemblies of installations, engineering podrazdeleniya, and earth-digging machines, and also to evaluate the degree of anti-nuclear defense achieved as a result of the engineering operations.

Thus, in our opinion, it is expedient to make operational-tactical calculations on the preparation of the terrain for the achievement of a certain degree of anti-nuclear protection. It would seem that the development of the proposed methods of calculation should be continued. The compiling of graphs and tables on the basis of solution of the equations is within the capabilities of the staffs of any rocket troops, in which there are many officers with good mathematical training and capable, by way of scientific-research work, of working out practical methods of calculating the engineering preparation of the terrain.

One of the methods of speeding up this preparation of the position areas, as has been mentioned, is the timely distribution of ready assemblies of installations. This frees the troops from the laborious work of procuring timber and preparing the construction of shelters and dugouts, which, of course, reduces the time of engineering preparation of the ground.

How can the [illegible] distributed among the chasti and podrazdeleniya to provide the greatest degree of protection to the rocket troops as a whole? Of all types of cover for personnel, the shelter, as we know, provides the greatest protection. However, the relative effectiveness of using shelters varies with the degree of nuclear pressure exerted by the enemy. With an increase in the number of nuclear attacks launched by the enemy on the deployment area or the launching sites, the relative effectiveness of shelters increases. On the other hand, with a decrease in the number of such attacks, the role of shelters in providing anti-nuclear protection is correspondingly reduced.

Therefore it is very important to determine, on the bais of military-scientific foresight and evaluation of the actual situation (terrain, concealment, place in the combat and operational formation, etc.), those units on which the enemy will probably launch the greatest number of nuclear attacks. These are the units to which should be allotted ready shelter assemblies, calculated to accomodate all their personnel. This decision is justified even when othr units, located in better situations, are not afforded the construction of shelters. With rocket troops usually not being in identical situations, an equal distribution of shelter assemblies is undesirable, as this might result in reducting the protection of the troops as a whole.

Construction of cover for personnel and combat equipment in itself may not provide protection unless there is established a certain regime of activity in the positions. A high degree of protection is attained when you have such a regime of combat activity as will reduce to a minimum the danger of destruction of personnel and combat equipment outside of cover. Therefore it is important to construct the various kinds of cover in the shortest possible time. But this depends not only on the availability of ready shelter assemblies and earth-digging machines, but also on the level of engineering training of the personnel. Thus the time required for preparing positions will also depend on how well-trained the rocket troopes are in fortification and concealment operations and how they are mobilized for rapid accomplishement of these operations.

Purposeful party-political support of engineering measures is also of great importance. There is no doubt that well-organized party political work is an important factor in increasing the speed of preparation of positions.

In considering the problem of increasing the anti-nuclear protection of troops, one cannot ignore the importance of their concealment (maskirovka). Concealment, we know, contributes to such protection, and it must be given due attention. Operational concealment is especially increasing in importance. The uncertainty of the situation and the highly maneuverable nature of the combat operations of rocket troops create favorable conditions for the wide and effective use of such measures.

Engineering support of the combat act[illegible] an offensive operation will be organized in a rapidly changing situation. Time for disseminating the information received for making decisions as to engineering preparation, and for carrying out the engineering work, will be limited. However, despite the difficult conditions, there must be clear-cut organizations of the engineering preparation and firm control of the engineering podrazdeleniya.

How can this be achieved in a compressed period of time? It seems necessary, in the first place, to increase the independence of rocket troops in accomplishing engineering tasks; secondly, to facilitate and simplify planning of engineering preparation; third, wherever possible, to plan in advance. In headquarters it would be expedient to mechanize and automate the most laborious processes of command--the collection, processing and transmittal of available information, and also the making of calculations for organization of the engineering preparation. Combat engineers need still more duplicating and calculating machines and sets of conventional signs for making charts, graphs and tables. Moreover, for direction of engineering podrazdeleniya, it is desirable to organize independent engineer-support radio nets, and to allocate the necessary signal equipment for this.

The success of engineering support of the combat activities of rocket troops will depend to a great extent on the quantity of engineering personnel and equipment. Therefore, no matter in how difficult a situation rocket troops may be operating, all steps should be taken for them to be strengthened by prompt receipt of engineering units and equipment. Along with this it is important that the most difficult and large scale engineer work be done for the rocket troops by forces and equipment of the senior combined arms commander.

Further theoretical and practical working out of problems of engineering support will contribute to successful combat use of rockets in a large offensive operation.

<u>Notes:</u>

1. <u>Deystviye yadernogo oruzhiya</u> (The Effects of Nuclear Weapons), <u>Translated from the English,</u> Voyenizdat, 1963; pp 130, 165.

2. <u>Deystviye yadernogo oruzhiya</u> (The Effects of Nuclear Weapons), <u>Translated from the English,</u> Voyenizdat, 1960; pp 114, 244.

3. <u>Deystviye yadernogo oruzhiya</u> (The Effects of Nuclear Weapons), <u>Translated from the English,</u> Voyenizdat, 1963; pp 130,624.

THE PROBLEMS OF ANTIMISSILE DEFENSE IN THE US

by Engr-Lt Col V. ALEKSANDROV

Scientific research and experimental design work in the field of antimissile defense has been conducted in the US for more than 10 years. Nevertheless the entire complex of difficult problems connected with creating an effective system of antimissile defense seems further from solution than it did four or five years ago when on the pages of the foreign press a fierce controversy raged over the Nike-Zeus antimissile system. This is not because the US command and government has not given this question sufficient attention, but because of a number of other reason. To understand this it is necessary to examine the work which has already been done in the US, and also to evalutate the expenditures of forces and means connected with this work.

Already in 1957 definite directions were noted in the work being conducted in the US to create means of long-range and extra long-range detection of missiles and means for intercepting and destroying them. Particular attention had already been given to special radar stations with ranges of 4,000-5,000 kilometers for detection of small targets such as the nose sections of intercontinental ballistic missiles. Active antimissile systems included the Nike-Zeus, Plato, and Wizard systems, which in principle embraced three basic directions: defense of objectives (Nike-Zeus system), troops (the Plato system), and the country (the Wizard system).

Work connected with the creation of radar stations for the long-range detection of missiles in flight was successfully completed: the US created the AN/FPS-17, AN/FPS-49 and AN/FPS-50 stations with ranges of 1,600, 4,000, and 5,400 kilometers, respectively. Stations of the last two types were used in the BMEWS long-range detection system, which was completed in 1963. This system provides, at least theoretically, a 15 to 17-minute warning of the approach of missiles from the north to objectives located on the territory of the US.

The original plans of active systems of antimissile defense failed. The troop system Plato proved to be too complex and cumbersome, and its development was discontinued in 1959. The Wizard system, which was intended to be used for intercepting missiles at ranges up to 1600 kilometers, met with the same fate. The remaining system, Nike-Zeus, was brought up to the stage of flight tests, which began in September 1959. In 1962-1964 extensive testing of this system was conducted with firings against the nose sections of actual Atlas D and Titan 1 missiles.

The scope and intens[illegible] be judged from certain figures on the expenditures for this purpose and from the number of test firings. From the beginning of development to 1 July 1963, 1,372,000,000 dollars were spent on the Nike-Zeus system,[1] in the 1963/64 fiscal year -- 89 million dollars; and in the 1964/65 fiscal year 40 million dollars were allocated for completing the testing of the system. Thus, the total expenditures on the development and testing of this system were nearly 1.5 billion dollars. By 24 October 1962, 43 firings of the Nike-Zeus missiles had been conducted, and in the first phase of systems testing -- from 24 October 1962 to 5 July 1963 -- there were 17 firings[2], of which 15 were successful. By March 1964 Nike-Zeus missiles had made ten intercepts of the nose sections of the US Atlas D and Titan 1 intercontinental ballistic missiles.[3] The Nike-Zeus missiles were launched from Kwajalein Island in the Pacific Ocean, and the Atlas and Titan missiles were launched from Vandenburg Air Base (California) on the Pacific coast of the USA. Despite the relatively good test results, the US had to decide against adopting this system. Actually, the fate of the system was decided before completion of the tests, since it was pronounced insufficiently effective, and since the deployment of this system would cost billions of dollars. The entire complex of this system -- including the Nike-Zeus missiles, five cumbersome and complex radar stations, and complex electronic computers -- could conduct fire against only one rocket since the system was constructed on a single-channel principle. Moreover -- and this is most important -- with this missile the US could not solve one of the most difficult problems of antimissile defense -- discerning the actual target when the enemy uses interference and dummy targets. The method of compaing the reflected signals with characteristic signals from actual targets which have been studied and fed into the memory of computers in advance was pronounced unsatisfactory.

The fate of the Nike-Zeus system was shared by many systems intended for both the passive mission of antimissile defense (the detection and recognition of targets) and the active mission (the destruction of the nose sections of missiles in flight).

Already in 1959 and 1960, when the effectiveness of the Nike-Zeus system was in doubt, a number of other systems were proposed, including the active system Arpat for intercepting missiles in mid-course with one rocket of several small intercepter missiles, the Bambi system intended for the destruction of missiles in the powered phase of their flight with missiles launched from artificial satellites, and a system of detecting missile launchings by means of the artificial satellite Midas.

The Arpat system, although it provided for a considerable increase in the number of destructive elements in comparison with Nike-Zeus missiles, was not without a basic deficiency: it could not reliably distinguish between actual and dummy targets. The Midas system was intended for the detection of rocket launchings after the rockets had risen to a altitude of 10 to 12 kilometers by the infrared radiation of the flame jet of rocket engines. The US spent 225 million dollars on the development of the system and the launching of experimental satellites.[4] They were able to achieve certain successes in the creation of extremely sensitive and miniature detectors of infrared radiation and in a number of cases registered from space the launchings of their missiles from Altantic and Pacific missile ranges. Nevertheless this system had to be abandoned.

The apparatus aboard satellites proved to be extremely complex and could operate only several hours in orbit since the detectors of infrared radiation had to be cooled to very low temperatutes by means of liquefied gases. Moreover, the stumbing block in this system proved to be the difficulty in solving the problems of reliably distinguishing a signal from a missile in flight from the background noise of signals from various other sources, both earthly (forest fires, slag heaps, etc) and atmospheric (the reflection of sun rays by clouds). Finally, the Midas system proved to be too cumbersome and expensive. For the prompt detection of each missile launched the system would have had to consist of dozens of satellites with relatively short periods of active operation. For each satellite which ceased to function a new one would have to have been launched. The Midas system would have been effective only if each signal detecting a missile launch received by it were immediately transmitted to a center for evaluation and comparison with other incoming data. Therefore it would have been necessary to include in the system many ground control' and communications stations spread over entire continents or to have used communications satellites for transmitting signals. In the latter case a system of satellites with transmission links of the type "space-to-space-to-ground" would have been required. Even simpler space communication systems of the type "earth-to-space-to-earth" has still not been brought up to operational use, and a system for the Midas satellite would probably require at least 4-5 years.

In analyzing the scientific research and experimental design work on the Midas system, the US concluded that this system could not be put into operation earlier than 1969. This system would cost 2-3 million dollars and the yearly maintenance cost of the system would be at least 100 million dollars.[5]

It should be noted that the abandonment of the Midas system does not represent a complete cessation of the development of systems for detecting missile launchings by artificial earth satellites. This work is continuing, but with considerably less intensity than before 1963, and only in the research phase.

The curtailment of work on space means of detection is explained not only by their high cost and complexity, but by still another factor mentioned by President Johnson during pre-election polemics with the

Republican candidate, Goldwater. There is talk of erecting in the US special radar stations using the principle of deflected-return probing and capable of detecting objects located at the limits of the radio horizon. According to the President of the US, these radar stations will "literally peer around the curvature of the earth, informing us of aircraft and especially of missiles several seconds after their launchings."[6]

Stations using deflected-return probing have been under development in the US since 1958 in projects Tepee and Madre. A beam from this kind of station is directed at the ionized upper layers of the atmosphere and can be reflected from these layers and from the surfaces of the earth or sea, in this manner traveling around the earth. It has been demonstrated, for example, that a beam from a station located on the North American continent, after being twice reflected from layer F (altitude approximately 160 kilometers) can look over the territory of the USSR. A signal reflected from the cloud of ionized gases formed during the launching of a large rocket can be received by a station and used for determining the approximate azimuth and distance to that cloud. It is also possible to receive a direct signal distorted as a result of the absorption of energy by an ionized mass of gases. After triple reflection from layer F this signal can be received in the Indian Ocean by stations located on islands or on ships of a radar patrol.

In the long competition between the Midas system and the stations of deflected-return probing, the latter is winning at present.

Thus, in 1963 the US rejected two possible concepts of antimissile defense with the intercept of missiles during the initial powered-flight phase of their trajectory (the Bambi system) and during the middle part of the trajectory, which lasts from the moment of separation of the nose section of the missile until its rentry into the dense layers of atmosphere at an altitude of approximately 100 kilometer, when it is already near the target (the Nike-Zeus system). At present the main efforts of the US are being concentrated on the development of a system of intercepting the nose sections of intercontinental ballistic missiles during the final phase of their trajectory, after their entry into the dense layers of the atmospehere. This is the only concept which is seriously being studied by US specialists, even though its realization is connected, i their own opinion, with very great difficulties.

The results of the work conducted in the area of antimissile defense was presented in a report of the deputy chief of the Advanced Research Projects Agency of the US Department of Defense, Dr. Herzfeld, published in the press at the beginning of 1965.[7] According to the report, the total expenditures on the development of antimissile defense means up to that time amounted to 2-2.5 billion dollars.

The main advantage of a system for intercepting the nose sections of missiles after they have re-entered the dense layers of the atmosphere is the possibility of reliably distinguishing the target by means of atmospheric filtration, i.e. the natural separation of the actual target from possible dummy targets as a result of their different deceleration by the atmosphere. The main difficulties in creating such a system are the time limitations (an intercept at low altitudes must be made within 30 seconds) and the necessity of providing high reliability, approaching 100 per cent.

In principle, it is considered possible to use antimissile missiles with either nuclear charges or charges of conventional explosives. In the first instance it would be possible to get a high reliability of destruction, but the nuclear blast would create interference for the further operation of the radar station systems and the intercept of other nose cones. It is estimated that the explosion of a nuclear charge of an antimissile missile of relatively small power would not create a serious danger for one's own troops and population; however, in the event of an explosion of the charge of the nose section of the target rocket at a relatively low altitude, there will be a very real danger and, consequently, special measures in regard to the construction of sturdy installations for the protection of military objectives and shelters for the civilian population would be required. In the second instance, the destruction of a target as solid and small as the nose section of an intercontinental ballistic missile will be relatively low and the danger of a possible explosion of the charge of the target rocket will be the same as in the first instance. Therefore, in this intercept system it is considered advisable to use antimissile missiles with nuclear charges.

A new concept of antimissile defense emerged with the development of the Nike-X system, in which improved Nike-Zeus missiles would be used along with new equipment. The basic elements of this system are missiles of the Nike-Zeus type, new Sprint missiles, MAR and MSR radar stations, and improved ground equipment for intercept control.

In recent years the Nike-Zeus missile has been considerably improved and extensively tested in firings against missiles and space targets. Testing conducted in 1963 and 1964, after the decision not to deploy a Nike-Zeus antimissile defense system, had the purpose of determining the possibility of using this missile in the Nike-X antimissile defense system and in a system of intercepting space targets which was being developed at that time.

The missile is a three-stage rocket with solid-fuel engines in all three stages and a nuclear warhead. The overall length of the missile is 14.6 meters, its maximum speed is approximately 3600 meters per second, and its range is over 240 kilometers. The missile is directed to a target by a command system using special radar stations.[8] It has been reported that this missile successfully intercepted a satellite passing near the island of Kwajalein, and is the principal element in one of two systems of antispace defense which have been created in the US.[9] The complex of this system has been set up on the island of Kwajalein. The second system uses interceptors carried into space by the rocket carrier Thorad, and can supposedly make intercepts at altitudes up to 640 kilometers. It has also been tested in firings against US satellites, using a device for registering the degree of miss instead of a warhead. This system was used to intercept the Transit, a US satellite which had ceased to function.

In the Nike-X system of antimissile defense the Nike-Zeus missiles are to be used in the first line of defense to intercept the nose sections of missiles at great altitudes prior to their entry into the dense layers of the atmosphere. The US is not counting on these missiles to be highly effective, especially in event of a "serious threat," and considers that they will be able to destroy only certain targets.

The Sprint missile, in the second line of defense, is intended for the intercept of the nose sections of missiles after the atmospheric filtration of dummy targets. It is a conical-shaped, two-stage missile 8.2 meters in length with a maximum diameter of 1.37 meters, a radio command guidance system, and solid-fuel engines in both stages. The first stage of the rocket does not have a fin assembly, and apparently the missile is not guided during the operation of this stage.[10]

Sprint missiles must be launched from underground silos by means of a special system using hot or cold gases. The engine of the first stage is turned on after the ejection of the missile from the launching silo and in a short operating time of several seconds it imparts hypersonic speed (greater than Mach 5) to the missile. It is believed that in that phase of flight the missile can execute only limited maneuvers according to a predetermined program.

For the development of the Sprint missile the experimental two-stage missile Squirt was built. Its first stage is a cluster of seven Recruit solid-fuel engines of the Thiokol firm, and the second stage is a cluster of seven Cherokee solid-fuel engines made by the same firm. The nose cone of the missile is intended for testing various materials under the intense heat generated during movement through the dense layers of the atmosphere.

Another experimental missile has been created by the Boeing firm especially for the study of problems of stability and flight control during the very high rates of acceleration (approximately 100 G's) which the Sprint missile will develop during acceleration and maneuver while still in relatively dense layers of the atmosphere. This single-stage missile is approximately six meters long; its body consists of three sections -- the tail section (with the engine nozzle), the center section (with a solid-fuel engine built by the Hercules Power firm) and a nose section containing the payload (research apparatus). A series of experiments with these missiles was begun on the White Sands Test Range.[11]

The MAR radar station takes the place of three stations of the Nike-Zeus system and can simultaneously detect, recognize, and track a large number of targets. Using this station, the complexes of the Nike-X system can simultaneously conduct fire against many targets. This station has a phased antenna array and an electron-beam scanning system One of its advantages is that it has no moving parts. The maximum range of an MAR station is estimated at 3200 kilometers, its average radiation power is 1-10 milliwatts, and its peak power is 100-1,000 milliwatts. Supposedly, one such station can service several antimissile defense complexes located in three or four different states. A prototype of the MAR station was constructed by the Bell Telephone Laboratories and in the summer of 1964 it was set up on the White Sands range for testing.

The MSR radar station is intended for directing antimissile missiles to selected targets. Like the MAR station, it has phased antenna array and an electron-beam scanning system. Each antimissile defense complex must have one MSR station connected with the MAR stations and a central control post.

In addition to a MSR station an antimissile defense complex may also have infrared and ultraviolent installations for tracking approaching nose sections of missiles.

For the development of the Nike-X system the US Government allocated 246 million dollars in 1963/64 and 334 million dollars in the 1964/65 fiscal year.[12] This is a relatively small amount and it is designated for experimental design work and the testing of separate elements of the system. The cost of deploying this system is estimated at between 12 and 20 million dollars.[13]

Why hasn't the US, despite rather extensive scientific research and experimental design work in the field of antimissile defense, settled on some kind of definite plan for a system and begun actual construction of it?

There are many reasons: the imperfection and insufficient effectiveness of the systems which have been studied (technical reasons), the extremely high cost of deployment and the relatively small political advantages over the enemy which would be achieved by the very costly wide or even partial deployment of a system of limited effectiveness. But these are not the only reasons.

The Dr. Herzfeld mentioned above evaluated the work which has been conducted in this area. At first glance this evaluation seems paradoxical. This scientist and important military leader of the US Defense

Department considered the most important result of all the work on an antimissile defense, which cost the US over two billion dollars, to be

the compilation of data for improving offensive weapons and for developing means to facilitate the penetration of an enemy defense with US intercontinental ballistic missles.

It should be noted that work on an antimissile defense and on ways of overcoming such a defense is being conducted simultaneously in one huge project known as the Defender Project, for which yearly allocations have for many years exceeded 100 million dollars. Thus, antimissile defense and anti-antimissile defense is being examined by the US as two sides of the broad problem of effectiveness of modern means of offense and defense. In every phase of this work it has been shown that the development and perfection of offensive means are more promising, cheaper, and simpler.

In the opinion of Herzfeld there theoretically is no antimissile defense which cannot be overcome by an enemy. The more effective an antimissile defense system, the greater the expenditures which will be required to overcome it. However, these expenditures do not compare with the cost of deploying the defensive system. And this is the most important advantage of means of penetrating antimissile defense: They can be extremely effective with relatively small expenditures.

Means of overcoming antimissile defenses are intended to make it difficult or impossible to detect a nose cone in flight, and also to make it difficult to destroy after detection.

In the initial, powered-flight phase of its trajectory, a missile is difficult to detect but easy to hit, even with a conventional infantry weapon. In the middle phase the separate nose cone is difficult to hit, but wide use may be made of interference and dummy targets to deceive the enemy and neutralize his means of tracking and recognizing targets, thereby reducing as much as possible the time for their intercept and destruction. In this phase measures can be taken to decrease the effective reflecting surface of a missile's nose cone. During re-entry into the atmosphere, when atmospheric filtration simplifies recognitition of the target and screens out dummy targets, it is possible to use certain methods such as additional acceleration of the nose cone, its movement at a great angle to the horizon to reduce the time during which it can be intercepted, and finally the use of a maneuvering nose cone, capable of sharply changing its trajectory and switching to a new target, thereby mullifying the results of the tracking and the calculations for determining the point at which the intercept of the nose cone should occur. After work on the Bambi project had been haltered and the work on the Midas project had been suspended, the main interest in the US was concentrated on the development of means of overcoming a typical antimissile defense for the second and third phases of a millile's flight.[14]

... first methods of overcoming an antimissile defense. Whereas in 1950-1952 the effective reflecting surface of a nose cone was considered to be approximately 0.2 square meters, it is now estimated that with the use of pointed and oriented nose cones and of ablatious coatings this surface can be reduced by a factor of 1,000.

Dummy targets are considered one of the simplest means of deceiving an enemy. Light-weight dummy targets -- inflatable balloons of thin aluminized material, corner reflectors, and metal chaff -- are considered effective means only in the middle phase of the flight trajectory of a nose cone, since upon entry into the atmosphere they are separated from the actual target. For the imitation of infrared radiation the nose cone, upon entry into the atmosphere, must use special heat decoys (these are being developed for infrared and visible ranges by the Hughes firm in the program Opadek). Finally, heavy dummy targets, which can themselves carry chaff or inflatable balloons and which have heat-resistent coatings, can be used to imitate the nose cone in the middle phase of the trajectory and during entry into the atmosphere.

Reportedly, dummy targets made by the Aeroneutronics firm have been used by the US with the Atlas and Titan missiles and are to be used with Minuteman missiles.

Active radio interference can be created by transmitters installed in nose cones and in small dummy targets. In the opinion of the US, the second way is preferable, since a nose cone escapes destruction while a defensive missile is being directed to the interference. The dummy targets must be equipped with receivers, devices for analyzing the signals of radar stations of the antimissile defense, and interference transmitters for reproducting the signals reflected from the nose cone. The development and testing of means for creating active interference is being conducted in the US by the Sperry Rand, Avco, Aeroneutronics, Raytheon, and Lockheed firms. The Raytheon firm developed the PX-3 and PX-4 jammers for the Polaris A-2 missile.

Maneuvering nose cones have been developed by the McDonnell and General Electric firms. These nose cones can change their trajectories by means of small engines prior to re-entry into the atmosphere or maneuver in the dense layers of the atmosphere by using aero dynamic forces. One of the variants is a nose cone with several warheads having separate trajectories and intended for the destruction of various targets. At present the Americans are studying the possibility of building a Mk 17 nose section for the Minuteman 2 and Posidon missiles.[15]

Still another means of overcoming an antimissile defense with special missiles intended for the destruction of radar stations of a defense system has been observed. Work in this direction is being conducted by the Lockheed [illegible] launched when desired or separated from the nose section of the main missile upon entry into the atmosphere.

The data presented above shows that a wide arsenal of technical means may be used to overcome an antimissile defense. Work on creating such means has been conducted in the US for a long time, but it has acquired special scope in recent years. Whereas in the 1961/62 fiscal year the allocations for this purpose totaled 35.5 million dollars, in 1962/63 and 1963/64 they reached 119 million and 155 million dollars, respectively. To date the US has spent nearly one billion dollars on the development of means for penetrating an antimissile defense.[16] Whereas prior to 1965 the money was spent mainly on scientific research and experimental design work, since 1965 it has been spent primarily on the production of previously developed and tested means of overcoming an antimissile defense.

Thus, the development of means of overcoming an antimissile defense has, in the view of the US, outstripped the development of antimissile defense systems. This does not mean that the US is not making an effort to develop an antimissile defense system of at least partial effectiveness. On the contrary. Although the US has not reached the point where it can make a decision on the deployment of an antimissile defense system, scientific research and experimental design work in this area is continuing on an ever increasing scale. New programs and projects are constantly appearing in the press.

It is expected that allocations for the development of the Nike-X system will reach approximately 400 million dollars in the 1965/66 fiscal year, and that more than 100 million dollars will be allocated for the Defender Project. Among research projects mentioned in the press, for example, are the US Air Force project for developing the HiBEX antimissile missile, which is suppose to develop even greater acceleration than the Sprint, and the Albis missile project being developed at Johns Hopkins University. It was recently reported in the press that work on the Arpat Project is continuing and that a radar station called Armand is being developed for that system. The US Army has reportedly already made several successful missile intercepts with Arpat missiles.[17] There are indications that this missile is to be used in an antimissile defense of fortified positions for the intercept of missiles at still lower altitudes than the Sprint missile. The Stanford Research Institute of the USA is conducting work in the field of antimissile defense according to several contracts with the US Army, including the development of the Lars radar station, intended for tracking and identifying missiles flying at relatively low altitudes. Finally, the successful beginning of the flight testing of the Sprint missile should be noted. The first launching of this missile was made at the White Sands range on 26 March 1965. According to the press, the results of the launching exceeded the expectations of US specialists.

Also deserving attention is the extremely wide range of experiments and tests which the US intends to conduct in 1965 and 1966 in the Nike-X program and the related Project Abres (the study of flight dynamics of missile nose cones and means of facilitating their penetration of antimissile defense systems). A considerable part of the Atlas and Titan 1 missiles are to be used for this purpose. By April of this year 27 Atlas D and Atlas F intercontinental ballistic missiles had been earmarked for this purpose, and a total of 160 rockets of the Atlas type are to be used in the Nike-X and Abres programs. In some experiments the rockets will be launched from silos.[18]

From the information presented in this article, it is obvious that the search for a solution to the problems of antimissile defense is continuing in the US. This work is taking into account the problems of overcoming an antimissile defense, the creation of civilian defense under conditions of nuclear-rocket war, the status and development of means of attack, economic considerations, the political situation, and other factors. The first real antimissile defense system is the US may be the Nike-X system, which, if its test are successful, could not be deployed before 1966-1967.

Notes

1. Aviation Week and Space Technology, April 22, 1963.
2. Flight, August 1, 1963.
3. Missiles and Rockets, March 9, 1964.
4. Missiles and Rockets, February 3, 1964.
5. Aviation Week and Space Technology, February 3, 1964.
6. Time, September 25, 1964.
7. Missiles and Rockets, January 18, 1965
8. Air Force/Space Digest, May 1964.
9. Aviation Week and Space Technology, September 28, 1964.
10. Missiles and Rockets, November 23, 1964.
11. Flying Review, January, 1965.
12. Missile/Space Daily, January 28, 1964.
13. Missiles and Rockets, March 9, 1964.
14. Space/Aeronautics, February 1964.
15. Aviation Week and Space Technology, February 1, 1965.
16. Electronics, January 11, 1965.
17. Electronics News, March 8, 1965.
18. Interavia Air Letter, March 22, 1965.